JUMPER CABLE MODULE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to electrical and optical equipment.

Description of the Related Art

Voice and data communications equipment is often designed such that printed circuit boards fitted with faceplates are inserted side-by-side into card cages. Connectorized assemblies (e.g., fiber optic jumper cables terminated at each end with a connector) are used to transmit (optical) signals from point to point within the card cage, e.g., from the circuit board to the faceplate, between two points within the same circuit board, between two different circuit boards, etc. Typically, four to eight fiber optic jumper cables may be used per circuit board in a cage. In some instances, an even greater number of jumper cables per circuit board may be required. Additional fiber optic jumper cables may also be needed for connections between different card cages, cabinets, or shelves.

Under current practice, two ends of a fiber optic jumper cable are connectorized and manually attached to the specified points, e.g., to the circuit board and faceplate. The amount of slack in the fiber between the points of attachment may vary depending on the distance between those points, length of the jumper cable, and other geometrical or topological constraints. In addition, jumper cables are often intentionally made longer than would be necessary to make the specified connections in order to have an extra length of fiber for repairs, such as replacement of broken connectors or removal of damaged sections of fiber. For these reasons, fiber optic jumper cables often end up dangling, jutting out, or otherwise protruding, e.g., from the surface of the circuit board.

During installation and/or maintenance, circuit boards are usually inserted into and/or pulled out of the card cage. An often occurring problem is that a dangling or protruding fiber optic jumper cable is damaged when it catches an obstacle, e.g., a piece of equipment within the cage, constriction of the card slot, or another jumper cable protruding from a different circuit board. Repair and replacement of the damaged fiber optic jumper cables may add significantly to the operational cost of telecommunication equipment.

SUMMARY OF THE INVENTION

In one embodiment, the present invention provides a jumper cable module for use with communication equipment. The module provides proper tensioning for jumper cables and retains them in a protected manner. The module includes a pulley and an eccentric cam pivotally

connected to a base plate. A jumper cable is wrapped around grooves in the pulley and cam such that the connectorized ends of the cable extend out and attach to particular connection points (e.g., on the same or on two different circuit boards). The cam is turned about its axle to produce the desired tension of the cable. For maintaining the tension, the cam may incorporate a tensioning mechanism, e.g., a spring-loaded ball mechanism or a serrated edge ratchet. When the cable needs to be removed from the module, the tensioning mechanism is disengaged and the cam is turned to create slack in the cable for ease of cable removal. A module that includes stacks of pulleys and cams may handle multiple jumper cables. The present invention can be used to reduce damage to and improve handling of jumper cables during installation and maintenance of communication equipment.

According to one embodiment, the present invention is a jumper cable module, comprising: (a) a pulley connected to a base plate; and (b) a cam pivotally connected to said base plate, wherein: the jumper cable module is configured to provide tensioning to a jumper cable (i) placed within the jumper cable module and (ii) connected to connection points, which tensioning is achieved by rotating the cam to a selected angular position.

According to another embodiment, the present invention is a method of tensioning a jumper cable connected to connection points, the method comprising the steps of: (a) placing the jumper cable within a jumper module, wherein the jumper cable module comprises a pulley connected to a base plate and a cam pivotally connected to said base plate; and (b) rotating the cam to a selected angular position to achieve desired tension in the jumper cable.

BRIEF DESCRIPTION OF THE DRAWINGS

Other aspects, features, and advantages of the present invention will become more fully apparent from the following detailed description, the appended claims, and the accompanying drawings in which:

Fig. 1A is a perspective view of a fiber optic jumper module according to one embodiment of the present invention;

Fig. 1B is a top view of the fiber optic jumper module of Fig. 1A illustrating the use of the module with fiber optic jumper cables of two different lengths;

Fig. 2 is a perspective view of a fiber optic jumper module according to another embodiment of the present invention;

Fig. 3 is a perspective view of a fiber optic jumper module according to yet another embodiment of the present invention;

Fig. 4 is a side view of the fiber optic jumper module shown in Fig. 3;

Fig. 5 is a top view of part of the tensioning mechanism of the fiber optic jumper module shown in Fig. 3; and

Fig. 6 is a perspective view of a fiber optic jumper module according to still another embodiment of the present invention.

DETAILED DESCRIPTION

Reference herein to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment can be included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Although the invention is particularly suitable for use with circuit boards and fiber optic jumper cables those skilled in the art can appreciate that the invention can be equally applied to other types of electrical or optical equipment and/or other types of cable, including electrical cables/wiring.

Fig. 1A shows a perspective view of a fiber optic jumper module **100** according to one embodiment of the present invention. Module **100** comprises a pulley **102** and an eccentric cam **104**. Both pulley **102** and cam **104** are connected to a base plate **106**. In one embodiment, base plate **106** may be part of a circuit board. In different embodiments, base plate **106** may be a separate board in a card cage or part of module **100**. Pulley **102** may have an optional axle **108** configured to rotatably connect pulley **102** to base plate **106**. In an embodiment that does not include axle **108**, pulley **102** may be fixedly attached to base plate **106**. Cam **104** is pivotally connected to base plate **106** using an off-center axle **110**. Cam **104** may also have an optional ear **116** that can be grasped for turning cam **104** about axle **110**. Along their respective perimeters, both pulley **102** and cam **104** incorporate grooves **112** and **114**, in which a fiber optic jumper cable **118** can be placed. Cable **118** typically includes connectors **120** that may be connected to particular connection points, e.g., on a circuit board or faceplate.

Fig. 1B shows a top view of module **100** and demonstrates the principles of using the module with fiber optic jumper cables of varying lengths. Illustratively, the operation of module **100** with a relatively long cable **118a** and a relatively short cable **118b** is shown. The following representative steps may be used to engage module **100**. Cable **118a** or **118b** is connected to a first connection point using one connector **120**. The cable is then placed within groove **112** of pulley **102** and optionally wrapped around the pulley within the groove one or more times. With cam **104** oriented at position C, the cable is then placed within groove **114** of cam **104** and connected to a second connection point using the other connector **120**. To remove any unwanted slack, cam **104** is then rotated (clockwise in Fig. 1B) about axle **110** to produce the desired tension in the cable. For example, for the relatively long cable **118a**, cam **104** is rotated clockwise from position C to position A and fixed in position A. Similarly, for the relatively short cable **118b**, cam **104** is rotated clockwise from position C to position B and fixed in position B shown by the

dashed line in Fig. 1B. For fixing the cam in a desired position, e.g., positions A or B, and maintaining the desired tension of the cable, cam **104** may incorporate a tensioning mechanism, possible embodiments of which are disclosed below in the context of Figs. 5 and 6. Subsequently, if cable **118** needs to be removed from module **100**, the tensioning mechanism is disengaged and cam **104** is turned back toward position C (e.g., counterclockwise in Fig. 1B) to create slack in the cable for ease of cable removal from groove **114** of cam **104** and/or groove **112** of pulley **102**.

In one embodiment, pulley **102** is a grooved disk having a radius of R_1, where R_1 is preferably larger than the greater of the acceptable bend radius of cable **118** (defined as the bend radius at which leakage of light from the optical fiber in the cable due to its curvature exceeds a predetermined level) and the critical bend radius of cable **118** (defined as the radius at which the optical fiber in the cable breaks). Cam **104** is a grooved plate, e.g., having the shape of a rectangle with rounded corners. Similar to pulley **102**, the rounding radius R_2 of the cam is chosen based on the acceptable and critical bend radii of cable **118**. Depending on the implementation, R_1 may equal R_2. Furthermore, different shapes, e.g., a bar, an oval, or a rounded triangle, may be utilized for pulley **102** and/or cam **104**. In addition, axle **110** may be centrally located on cam **104**.

Fig. 2 shows a perspective view of a fiber optic jumper module **200** according to another embodiment of the present invention. Module **200** comprises a stack **202** of pulleys **102** and a corresponding stack **204** of eccentric cams **104**. In one embodiment, stack **202** includes four pulleys **102** and stack **204** includes four cams **104**. Each individual cam **104** of stack **204** can swivel around axle **210** independently of the other cams in the stack. Also, each cam **104** of stack **204** can independently be fixed in a desired position using its individual tensioning mechanism.

In operation of module **200**, a fiber optic jumper cable is wrapped around a pulley **102** of stack **202** and inserted into the groove of the corresponding cam **104** of stack **204**, which cam and pulley are preferably located at the same vertical position in their respective stacks. Then, the cam is rotated and fixed as described above to produce the desired tension on the cable. This procedure may be repeated for each corresponding pulley/cam pair for a different fiber optic jumper cable. In the embodiment shown in Fig. 2, module **200** can accommodate up to four different cables. In different embodiments, stacks **202** and **204** may have more or fewer than four pulleys and cams, respectively, and accommodate a corresponding number of different cables.

Fig. 3 shows a perspective view of a fiber optic jumper module **300** according to yet another embodiment of the present invention. Module **300** comprises a stack **302** of four pulleys and a stack **304** of four cams. Therefore, similar to module **200** of Fig. 2, module **300** can accommodate up to four fiber optic jumper cables. However, a different structure for the stack of cams (stack **304**) is used in module **300** compared to that (stack **204**) in module **200**. Similar to stack **204**, stack **304** includes four cams **104**. Only one cam **104** of stack **304** is illustrated in Fig. 3 (see dashed line). The other cams **104** are not visible in the view presented in Fig. 3 except for

their ears **116**. In addition to four cams **104**, stack **304** also includes four round plates **305**, three of which are inserted between cams **104** and the fourth one is placed on top of the topmost cam **104**. In a preferred embodiment, each plate **305** is attached to cam **104** located beneath that plate such that the center of plate **305** corresponds to the pivoting point of cam **104**. Each cam/plate pair is rotatably connected to base plate **306** by an axle **310** of stack **304**. Plates **305** in module **300** serve the purpose of reducing the exposed length of cable within the module. In particular, plates **305** enclose and protect from possible damage at least part of the length of cable corresponding to sections DE and FG of cable **118a** of Fig. 1B.

Fig. 4 shows a side view of module **300**. Stacks **302** and **304** are pivotally connected to a base plate **306** using axles **308** and **310**, respectively. Module **300** may be attached to a board **322**, which can be, e.g., a circuit board, using spring-loaded legs **324**. In one embodiment, module **300** has two legs **324** located beneath the pivot points of stacks **302** and **304**. In different embodiments, one, three, or more legs **324** located at different points may be used. Each leg **324** has an elastic compressible head **326** and a spring **328**. To attach module **300** to board **322**, head **326** is squeezed and pushed though a round opening in board **322**, which opening preferably has a diameter slightly smaller than that of head **326**. After protruding through the opening, head **326** expands and locks spring **328** in a partially compressed state between base plate **306** and board **322**. The expansion force of spring **328** provides support for module **300**.

Fig. 5 shows a top view of a tensioning mechanism **330** of module **300**, also shown in Fig. 3. Mechanism **330** comprises sixteen nested holes **502** in each plate **305** of stack **304**, sixteen matching nested holes in each cam **104** of stack **304**, and sixteen matching nested holes in base plate **306**. The nested holes are arranged in a circle around axle **310** as shown in Fig. 5. Mechanism **330** further comprises at least four pairs of spring-loaded balls (not shown). At least one pair of spring-loaded balls is inserted between each cam **104** and plate **305** located beneath that cam such that the balls are nested in the matching holes. For the bottom-most cam **104**, at least one pair of spring-loaded balls is inserted in a similar fashion between that cam and base plate **306**.

In operation, tensioning mechanism **330** can fix each cam **104** of module **300** in sixteen different angular positions using the locking action of a spring-loaded ball settled into one of the sixteen nested holes of that cam. To change the angular position of cam **104**, that cam is rotated such that the spring-loaded ball skips and settles into a different nested hole. For the particular embodiment of mechanism **330** shown in Fig. 5, the angular position of each cam **104** in stack **304** can be changed with increments corresponding to about 22.5 degrees (i.e., 1/16-th of a full turn). In different embodiments of mechanism **330**, different increments may be implemented using a different number of nested holes.

Fig. 6 shows a perspective view of a fiber optic jumper module **600** according to still another embodiment of the present invention. Module **600** is similar to module **300** of Fig. 3. However, one difference between these two modules is that stacks **602** and **604** of module **600** include eight pulleys and cams compared to four pulleys/cams in stacks **302** and **304** of module **300**. Therefore, module **600** can accommodate up to eight fiber optic jumper cables compared to four cables for module **300**. Another difference between these two modules is the tensioning mechanism. Module **600** has a serrated edge ratchet, well known in the art, instead of mechanism **330** for module **300**. In different embodiments, other designs of tensioning mechanisms, such as button stopper, coil, or friction stopper arrangements, can also be applied. In general, any suitable tensioning mechanisms that can fix an individual cam in a desired position and maintain proper tension of a jumper cable may be used with jumper cable modules of the present invention.

Modules **100**, **200**, **300**, and **600** may be loaded with fiber optic jumper cables at the point of manufacture, by a third party, or at the point of installation onto a circuit board. A module can be part of a circuit board or a separate unit inserted into its own slot in a card cage. An operator or a robot may install the module onto a board, card cage, shelf, or cabinet. A jumper cable module of variable capacity can be implemented using a modular approach. In such a module, pulleys and cams are added/subtracted from the corresponding stacks as needed to increase/decrease capacity of the module. Various materials and methods of manufacture may be employed in producing the modules. For example, the modules may be made of plastic and produced using injection molding.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the described embodiments, as well as other embodiments of the invention, which are apparent to persons skilled in the art to which the invention pertains are deemed to lie within the principle and scope of the invention as expressed in the following claims.